"Meteorological Observations obtained by the Use of Kites off the West Coast of Scotland, 1902." By W. N. SHAW, Sc.D., F.R.S., and W. H. DINES, B.A. Received April 28,—Read May 14, 1903.

(Abstract.)

The paper presents the results of the first organised attempt to obtain a series of automatic records of temperature and humidity in the upper air of the British Isles, or neighbouring seas, by means of kites. They are derived from the records of forty kite ascents, in which instruments were raised, and which were carried out by Mr. Dines and his two sons, under the auspices of the Royal Meteorological Society in co-operation with a committee of the British Association, during the months of July and August, 1902. Two of the ascents were from a small island in Crinan Bay, Argyllshire, the remainder from the deck of a tug steaming in the Jura Sound or neighbouring sea. Kites were raised on seventy-one occasions, but, on thirty-one of them, the force of the wind, even when assisted by the speed of the tug at seven knots, was not sufficient to raise the recording instruments. On those occasions an experimental form of registering air thermometer alone was carried. The average recorded height of ascents with instruments was 5900 feet (1940 metres), and average computed height of the seventy-one ascents 4200 feet (1400 metres); a height of 12,000 feet (3700 metres) was passed on two occasions, and 15,000 feet (4500 metres) was reached once, but the record was lost owing to the breaking away of the highest kite.

The kites and winding gear were designed and constructed by Mr. Dines. Particulars are given in the Quarterly Journal of the Royal Meteorological Society, vol. 29, p. 65, 1903.

The average angular elevation given by the kites with a short length of line was 62° 30′, the greatest height reached with one kite was 5500 feet (1700 metres), with two 9200 feet (2800 metres), with three 12,400 feet (3800 metres).

The method of dealing with the records is described and illustrated. The results are expressed on a diagram representing, by a series of points and connecting lines, the height in the air of a series of temperatures with successive intervals of 1° C. for each ascent. The diagram thus presents a set of isothermal lines referred to time and height as co-ordinates. So far as the observations extend, the changes in the actual and relative positions of the lines show how the temperature varied at the surface and in the upper air during the period of the experiments.

On account of the unsatisfactory nature of the hygrometric records,

only four stages of humidity are dealt with, and these are entered upon the diagram, upon which are also recorded the observed heights of clouds entered by the kites, the direction of the wind at the surface and in the upper air, and particulars of the weather.

For the purpose of comparison the curves of variation of the barometer at Fort William and Ben Nevis, during the period of the experiments, are plotted on the same diagram, and certain particulars are also given about the temperatures of the wet and dry bulb at those stations.

From the diagram the fall of temperature for each 500 metres of each ascent is taken out and tabulated. The table gives the following average results.

Table of Fall of Temperature in Degrees Centigrade for each 500 Metres of Ascent.

		July.		August.	
0 to	500 metres	22 ascents	3°·0 C.	13 ascents	2°·6 C.
500	1000 ,,	16 ,,	2·8	11 ,,	2·8
1000	1500 ,,	9 ,,	2·2	9 ,,	2·3
1500	2000 ,,	2 ,,	2·0	7 ,,	2·1
2000	2500 ,,	1 ascent	2·0	3 ,,	2·0
2500	3000 ,,	—	—	2 ,,	2·0
3000	3500 ,,	—	—	2 ,,	1·7

The range of fall for the first 500 metres varied from 4° C. to 1° C. The smallest fall was associated with an inversion of temperature gradient not far from the surface. An inversion of temperature gradient with very dry air above a layer of clouds was shown also on one of the occasions of steepest gradient near the surface. The steep gradients observed in the lower strata are shown to be associated with anti-cyclonic conditions preceding the approach of a depression, and by examples on five occasions it is shown that the characteristic of the passage of a depression is that the isothermal lines of the diagram open out as the depression comes on, the average diminution of gradient for the change of barometric condition amounting to as much as 50 per cent.

The paths of the centres of depressions producing these changes are shown on the maps taken from the monthly weather reports of the Meteorological Office. It appears that they passed the station on all sides at various distances but none actually crossed it. The results show that whatever was the path taken by the centre, the column of air over Crinan became relatively much more nearly uniform in temperature under the influence of the depression, and therefore probably represented a relatively warm column of air.

The average of the values of temperature gradient in columns of

air of different heights derived from all the Crinan ascents are as follows :—

Height of column. Metres.	Temperature gradient. Per 100 metres.
500	0·56
1000	0·56
1500	0·52
2000	0·50
2500	0·48
3000	0·46
3500	0·43

It must be remembered that a moderately strong wind was required for the higher ascents, and they therefore refer to a more or less special type of weather. The gradients for the higher columns are accordingly not so generally applicable as those for the lower columns.

The results are compared with temperature gradients observed elsewhere as given in Hann's "Meteorologie," with the theoretical temperature gradient in dry air (1° C. per 100 metres), and with that for saturated air having an initial temperature 12° C. The last differs but little from 0·53° C. per 100 metres for all ranges up to 2000 metres and then increases. The average Crinan gradient is almost identical with this and with the conventional correction in use in this country for the reduction of temperatures to a common level, viz., 1° F. per 300 feet.

The last part of the paper is devoted to considering the differences between the temperatures as observed in the free air at the same height as the summit of Ben Nevis and those read on the mountain itself. The differences are always in favour of the free air, which is shown to be on the average 2·6° warmer than the mountain summit. Various circumstances are adduced to support the result, and an explanation is sought in the suggestion that the air flowing from the sea over the mountain would be mechanically raised and practically subject to the adiabatic gradient which is not reached in the free air. The consideration of the relative heights of clouds as observed on the hill sides and over the sea is adduced in corroboration.